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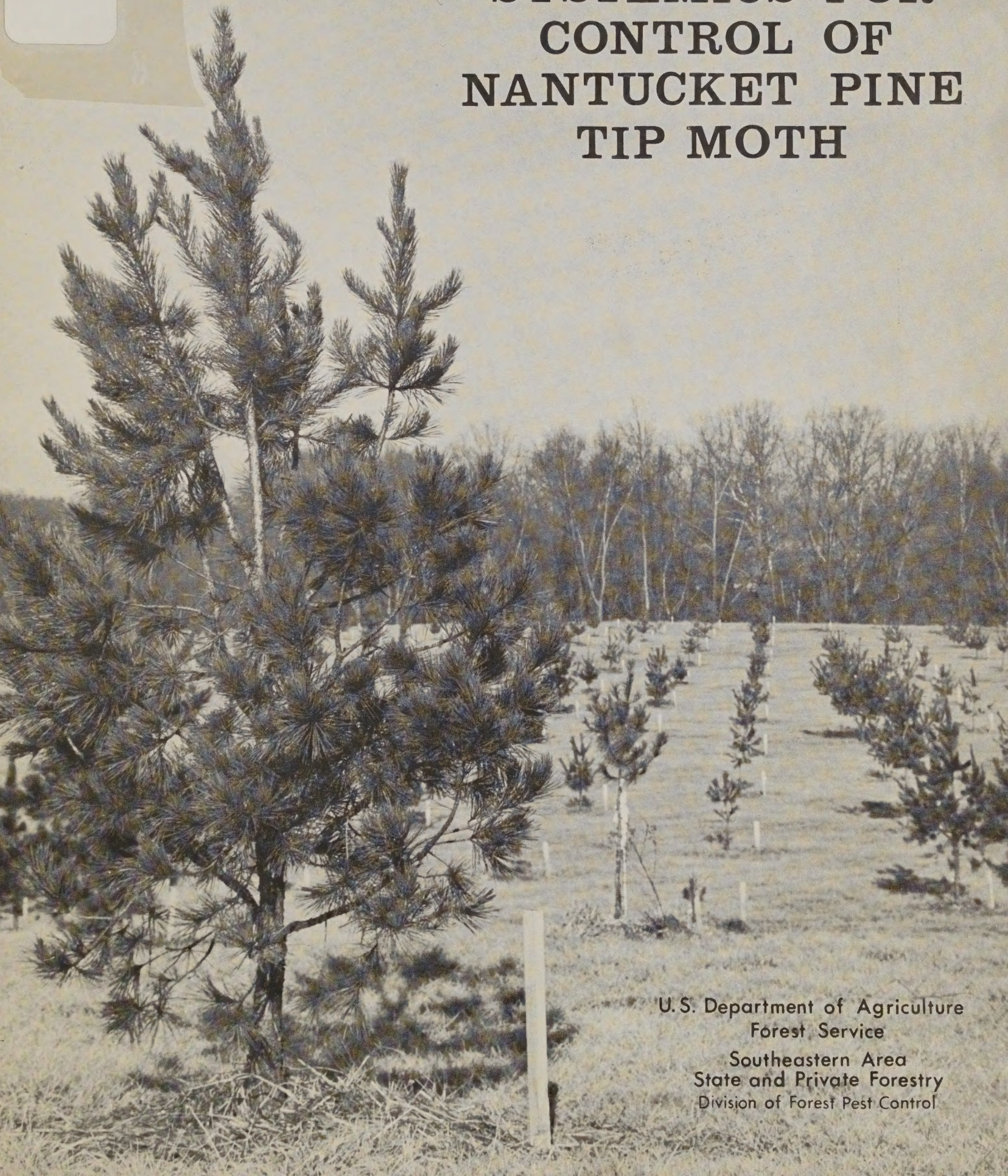

U.S. Department of Agriculture
Forest Service
Southeastern Area
State and Private Forestry
Division of Forest Pest Control

PILOT TEST OF SYSTEMICS FOR CONTROL OF THE NANTUCKET PINE TIP MOTH

By

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ABSTRACT

Results of a field pilot test of phorate systemic insecticide revealed excellent control of Nantucket pine tip moth in three to five year old grafted loblolly pine on the F. H. Claridge State Seed Orchard in Goldsboro, North Carolina. Trees treated with phorate once in early spring showed significantly less infestation than those treated monthly with DDT. The percent of infested tips in the phorate treated trees ranged between 1.5 and 3.7 percent depending on dosage level while those tips infested in the DDT treated trees exceeded 45.0 percent. Systematic irrigation of random phorate treatment blocks to determine relationship of water to the uptake and ultimate success of systemic phorate revealed no significant differences in degree of control. Analysis of living pine tips for phorate residue in July and September revealed that the parts per million residue remained high throughout the test and were actually climbing under some conditions at the climax of this test in September, seven months after initial application. The cost of phorate treatment was less than DDT.

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INTRODUCTION

Tip moths, *Rhyacionia* sp. are common pests of young pines throughout the southeast. The most prevalent member of this insect complex is the Nantucket pine tip moth, *R. frustrana* (Comstock) which is often found in association with closely related insects of the same genus. The larval stages kill terminal and lateral buds of pines by boring within them. The insects are capable of four to six generations per year which frequently result in heavy damage to young pine stands due to the repeated attacks occurring throughout the warm months of the year. Repeated attack can result in deformation of host tree, growth loss, cone crop reduction and in severe cases, mortality of host tree (Yates, 1960).

Reforestation efforts throughout the southeast have resulted in the establishment of seed orchards for propagation of superior seed of southern yellow pines. This effort has been and is presently hampered due to damage caused by tip moths of the genus *Rhyacionia*.

The cost of establishing and maintaining such orchards as well as realizing their ultimate value warrants the use of the most effective and economic control measures available. The recommended chemical control is a one-percent DDT spray. This measure has produced inconsistent results in the past due to the critical timing required in spray application. In addition to this difficulty, three or more spray applications are required per season to suppress the multiple generations of the tip moth. This repeated treating is time consuming and expensive.

Due to the inadequacies of DDT, various federal, state and private research agencies initiated and conducted studies to explore the potential in systemic insecticidal control. Two promising systemics that emerged as a result of this research were Thimet (phorate) and Cygon (dimethoate). Barras *et al.* (1957), Cade and Heikkenen (1965) and Mason (1965) reported phorate as an effective control agent against the tip moth. Barras *et al.* (1957), Butcher and Carlson (1961) and E. P. Merkel reported favorable control of tip moth using dimethoate.

Based on these results a field pilot test of these two systemics was designed and carried out in 1968 by the Division of Forest Pest Control, in cooperation with the North Carolina Division of Forestry. The purpose of the test was to bridge the gap between promising results of research and possible ultimate Forest Service adoption and use of the systemic compounds.

METHODS

Thimet 10-G†3 and Cygon 267†3 were the two specific compounds utilized in the pilot test. Thimet 10-G is a ten percent phorate concentration in a flowable granular form. Although possessing a high mammalian toxicity, safety precautions and procedures suggested by the manufacturers and early workers reduce application hazards to a minimum. Cygon 267 is a 30.5 percent emulsifiable concentrate containing dimethoate. Applied as a spray, Cygon has the advantage of being safer to handle than most of the other systemics.

The effectiveness of the two systemic insecticides mentioned above, hereafter referred to as phorate and dimethoate, were tested on a commercial field scale at different dosage levels on three seed orchards. Due to the extremely high values at stake in seed orchards, trees treated monthly with DDT were used as checks in lieu of untreated controls. This procedure left no valuable seed trees completely unprotected and at the same time provided a basis for the comparison of results. Untreated trees in surrounding areas were observed to verify the presence of tip moth populations.

The three seed orchards selected as test sites did not lend themselves to testing both of the systemic insecticides simultaneously because of limited size and layout. It therefore was necessary to test phorate on two of the orchards and dimethoate on the third.

Test Sites and Design

Ralph Edwards State Seed Orchard, Morganton, North Carolina – This orchard consists of approximately ten acres of four year old grafted

†3 Cygon [dimethoate (O, O-dimethyl S (N-methylcarbamoylmethyl) phosphorodithioate)]

Thimet 10-G [phorate (O, O-diethyl S - (ethylthio) methyl phosphorodithioate)]

Manufactured by the American Cyanamid Company, Thimet 10-G samples for this test were kindly furnished by the Agricultural Division of American Cyanamid, Princeton, New Jersey.

Virginia pine , *(Pinus virginiana* Mill.*)* and seven acres of four year old grafted shortleaf pine *(p. echinata* Mill.). Two dosage rates of dimethoate, one pound and two pounds of actual insecticide per 100 gallons of water, were applied monthly from mid-March to mid-August to replicated blocks in each of the two pine species represented. A one-percent DDT spray application was replicated at the same monthly interval to serve as the standard check.

All spraying was carried out with a John Bean 200 CP Speed Sprayer. The three experimental treatments (two levels of dimethoate and DDT) were set up in a randomized block design. Each block consisted of one row of 20 trees for each of the three treatments. Treatments were randomly assigned within each block. The test was replicated seven times in the *P. virginiana* and four times in the *P. echinata.*

Francis Marion Federal Seed Orchard, Moncks Corner, South Carolina — The test area of the federal seed orchard consists of 38 acres of loblolly pine *(P. taeda* L.) (Piedmont and Francis Marion source) grafted between 1964 and 1967. Twenty, 40 and 80 grams of phorate per tree were the dosage rates tested. The phorate granular insecticide was applied around the base of each tree in early March using an automobile-mounted apparatus designed and built by the Southeastern Forest Experiment Station (Fig. 1). Duff was raked away before application and replaced after treatment. A one percent DDT application was replicated on a representative number of trees at monthly intervals from March to August to serve as the standard check. The test was set up as a complete randomized block design, each block consisting of four experimental treatments (three levels of phorate and the check DDT). Treatments within blocks were randomly assigned to 20-tree rows. The test was replicated nine times.

F. H. Claridge State Seed Orchard, Goldsboro, North Carolina — This orchard consists of 45 acres of four year old grafted loblolly pine *(P. taeda* L.*).* Three dosage rates of phorate, 40, 80 and 100 grams per tree, were applied in early March. The methods of application were the same as those described previously on the Francis Marion Federal Seed Orchard. Monthly spray applications from March to September of one percent DDT were again used as the check and basis for comparing effectiveness. The four experimental treatments (three levels of phorate and the DDT) were replicated four times each under (1) normal environmental conditions and (2) under controlled moisture conditions.

The test utilized a split plot design involving two whole plots (irrigated and non-irrigated) and four split-plot treatments. Moisture was regulated with a functional sprinkler system in an effort to correlate moisture with the effectiveness of phorate at the various dosage levels. The irrigation was implemented with sprinkler heads spaced at 40 foot intervals throughout the designated irrigation area. Soil moisture meters placed in the irrigated and non-irrigated areas were read every third or fourth day. The irrigated area was maintained at soil moisture capacity throughout the test.

Field Observations

Field evaluations of each test orchard were conducted in early May, July and September, 1968 to determine the effectiveness of the respective systemics. During each of the field evaluations, each tree in the systemic insecticide and DDT treatment replicates were examined and the height, clone, treatment, species and number of tip moth-infested tips in the twenty uppermost branch-ends were recorded (Fig. 2). In the few cases where sample trees had less than twenty total tips, all the tips were tallied and a notation of the number recorded.

The work plan called for a statistical analysis of all data from each of the three orchards to determine significance of control differences between systemic insecticide and DDT. However, due to a collapse in tip moth populations and resultant lack of data on the Francis Marion Federal and the Ralph Edwards State Seed Orchards, a meaningful statistical analysis involving these two seed orchards was impossible (See results).

The field data collected in July and September[†4] from the F. H. Claridge State Orchard, where high tip moth populations existed, were analyzed in three separate ways for each of the monthly collection dates.[†5]

(1) Analysis of percent trees infested —

The tree was taken as the basic unit of observation and was classified as either infested or non-infested. The basic data item for each split plot was the percent of trees infested out of the total number on the plot. An arc sine $\sqrt{\%}$ transformation was carried out on the data before calculation of the analysis of variance.

†4 Very low tip moth populations prevented any analysis of May data.

†5 Statistical analyses provided by J. L. Clutter, Biometrician, Department of Forestry, University of Georgia.

Fig. 1 Applying the granular phorate systemic insecticide around the base of test tree.

ORCHARD_____ BLOCK_____ DATE_____

SPECIES_____ ROW(S)_____ LOCATION_____

TREATMENT_____

Tree #	Clone	Height	MAY		JULY		SEPTEMBER	
			# Tips Exam.	# Tips Infested	# Tips Exam.	# Tips Infested	# Tips Exam.	# Tips Infested

Fig. 2 Sample Data Sheet

(2) Analysis of percent tips infested –

The basic observation consisted of percent infestations – total tips infested/total tips observed. It was analyzed by pooling the data from all trees on a plot for each of the two collection dates. The number of tip observations on which the observed infestation percent was based was assumed to be the total source of variability within treatments.

(3) The third analysis method assumed that the variation in infestation-proness from tree to tree was so large, that the effect due to differences in the number of tips observed on individual trees was negligible. In this case the percent infestation of a given plot is the unweighted average of the infestation percents of each of the trees within the plot. Information concerning the variance relationship was obtained by computing for each plot the standard deviation of the per tree percent infestations and plotting these over the corresponding mean percent infestation values. This plotting indicated that the standard deviation increased linearly with the mean percent and implied that a log transformation could be used to stabilize the variances. The transformation used was $Y=\log_e (\% + 1)$.

Residue Analysis

On the F. H. Claridge State Orchard, approximately two pounds of distal six-inch pine tips were removed from each of six trees in July and from the same trees again in September. These four year old sample trees which were 6 ± 1 feet in height, were of the same clone and were representative of the three phorate treatments in the irrigated and non-irrigated replicates.

The samples were analyzed in the laboratory for toxic metabolites of phorate using an oxidative gas/liquid chromatography method[†6]. Pine tips from nearby untreated trees were also analyzed for use as standards. In this manner, it was possible to establish the existence, relative amounts in parts per million and variation in concentration of toxic phorate metabolite residue at the three phorate dosage levels tested.

Time and Cost Evaluation

Data to determine the economics of using phorate as compared to DDT were collected. This was accomplished through time studies on equipment use and comparative insecticide costs in relation to preparation and application.

Monitoring

The test of phorate on the F. H. Claridge State Orchard was monitored in regard to effects on warm blooded mammals and soil organisms. This program, which is still underway, is being conducted by the North Carolina Department of Conservation. Mr. Conley Moffitt, Chief Naturalist and head of the monitoring program, will continue to collect data during 1969.

RESULTS AND DISCUSSION

Systemic vs. DDT

Ralph Edwards State and Francis Marion Federal Seed Orchards – a population collapse of tip moth occurred in both these orchards during 1968. The field evaluations were carried through to their conclusion to verify the collapse and insure the test data in the event of a population increase.

The low level of tip moth activity on both these orchards prevented the determination of any significant differences between the effectiveness of systemic insecticide and DDT (Tables 1 and 2).

F. H. Claridge State Seed Orchard - High levels of tip moth activity in loblolly pine *(P. taeda)* on this orchard facilitated the collection of highly pertinent data in July and September on the relative effectiveness of systemic phorate vs. DDT. Due to initially low populations in May, data from the first field evaluation was insufficient for meaningful analysis. The data collected on the two latter evaluation dates in July and September were used as the basis for statistical analysis and the ultimate statements of conclusion.

All three methods of statistical analysis as described under METHODS indicated a decided superiority of phorate over the monthly application of DDT for control of the tip moth. Evidence of these significant differences are somewhat obvious in the summary data figures (Table 3).

†6 The laboratory analyses were kindly furnished by the American Cyanamid Company, Princeton, New Jersey.

Table 1 – Summary of Data on Pilot Test of dimethoate for Control of Nantucket Pine Tip Moth. Ralph Edwards State Seed Orchard, Morganton, North Carolina – 1968.

Treatment	Species	Number of Replicates	Total Trees	Total Tips Examined Bi-monthly	May	July	September	TOTAL	Percent Tips Infested
1.0 lb. dimethoate per 100 gal.	Virginia	7	139	2,651	4	1	1	6	0.23
	Shortleaf	4	78	1,499	8	2	1	11	0.73
2.0 lbs. dimethoate per 100 gal.	Virginia	7	136	2,628	4	1	2	7	0.27
	Shortleaf	4	77	1,441	4	1	1	6	0.42
DDT	Virginia	7	140	2,724	10	0	1	11	0.40
Check	Shortleaf	4	75	1,456	18	4	3	25	1.72

Table 2 – Summary of Data on Pilot Test of phorate for Control of Nantucket Pine Tip Moth. Francis Marion Federal Seed Orchard, Moncks Corner, South Carolina – 1968.

Treatment	Number of Replicates	Total Trees	Total Tips Examined Bi-monthly	May	July	September	TOTAL	Percent Tips Infested
20 Gram phorate Dosage	8	180	1,549	0	8	13	21	1.35
40 Gram phorate Dosage	8	176	1,554	0	2	7	9	0.58
80 Gram phorate Dosage	8	158	1,612	0	2	1	3	0.17
DDT CHECK	8	200	1,929	0	10	4	14	0.72

Table 3 — Summary of Data on Pilot Test of phorate for Control of Nantucket Pine Tip Moth. F. H. Claridge State Seed Orchard, Goldsboro, North Carolina — 1968.

Treatment	Number of Replicates	Total Trees	Total Tips Examined Bi-monthly	July	September	TOTAL	Percent Tips Infested
40 Gram Dosage:							
Irrigated	4	40	753	12	8	20	2.66
Non-irrigated	4	40	696	14	21	35	5.03
Combined	8	80	1,449	26	29	55	3.79
80 Gram Dosage:							
Irrigated	4	40	739	10	2	12	1.62
Non-irrigated	4	40	744	8	13	21	2.82
Combined	8	80	1,483	18	15	33	2.22
100 Gram Dosage:							
Irrigated	4	40	690	11	0	11	1.59
Non-irrigated	4	40	679	8	2	10	1.47
Combined	8	80	1,369	19	2	21	1.53
DDT Check:							
Irrigated	4	40	673	134	232	366	54.38
Non-irrigated	4	40	704	84	182	266	37.78
Combined	8	80	1,377	218	414	632	45.89

Overall, the aggregate number of total tips (632) infested in the DDT treatment was approximately 11 times greater than the number of infested tips (55) in the lowest phorate dosage per tree tested. As the phorate dosage increases to 80 and 100 grams per tree, the number and percent of infested tips correspondingly decrease. These differences are reflected in the graphical illustration of overall percent infestation (Fig. 3).

Separate analyses run for each of the data collection dates in July and September revealed significant differences in effectiveness during both months between the phorate and DDT (Fig. 4). As in the overall data, these significant differences for each data collection period reflect a superiority of all the phorate dosage rates over the DDT treatment. Although tip moth like other multigeneration insects tend to build up toward the end of the season, the higher 80 and 100 gram per tree dosage levels of phorate succeeded in reducing the presumably larger September populations below that recorded earlier in July. Even though populations in the lowest 40 gram per tree treatment tended to increase in September, damage was held to a tolerable level.

The three separate methods of analysis indicated that there was no statistical evidence of differential effectiveness among the three phorate treatments in July. In September, however, the 100 gram per tree treatment was shown to be significantly more effective than the 40 gram per tree treatment. One method of analysis also indicated that the 80 gram per tree treatment was more effective than the 40 gram per tree treatment.

Irrigation vs. Non-irrigation

None of the statistical analyses provided evidence of any effect due to irrigation or an irrigation-insecticide interaction in either July or September (Fig. 5). It is interesting to note, however, that as the dosage level of phorate increased, surplus water seemingly became less

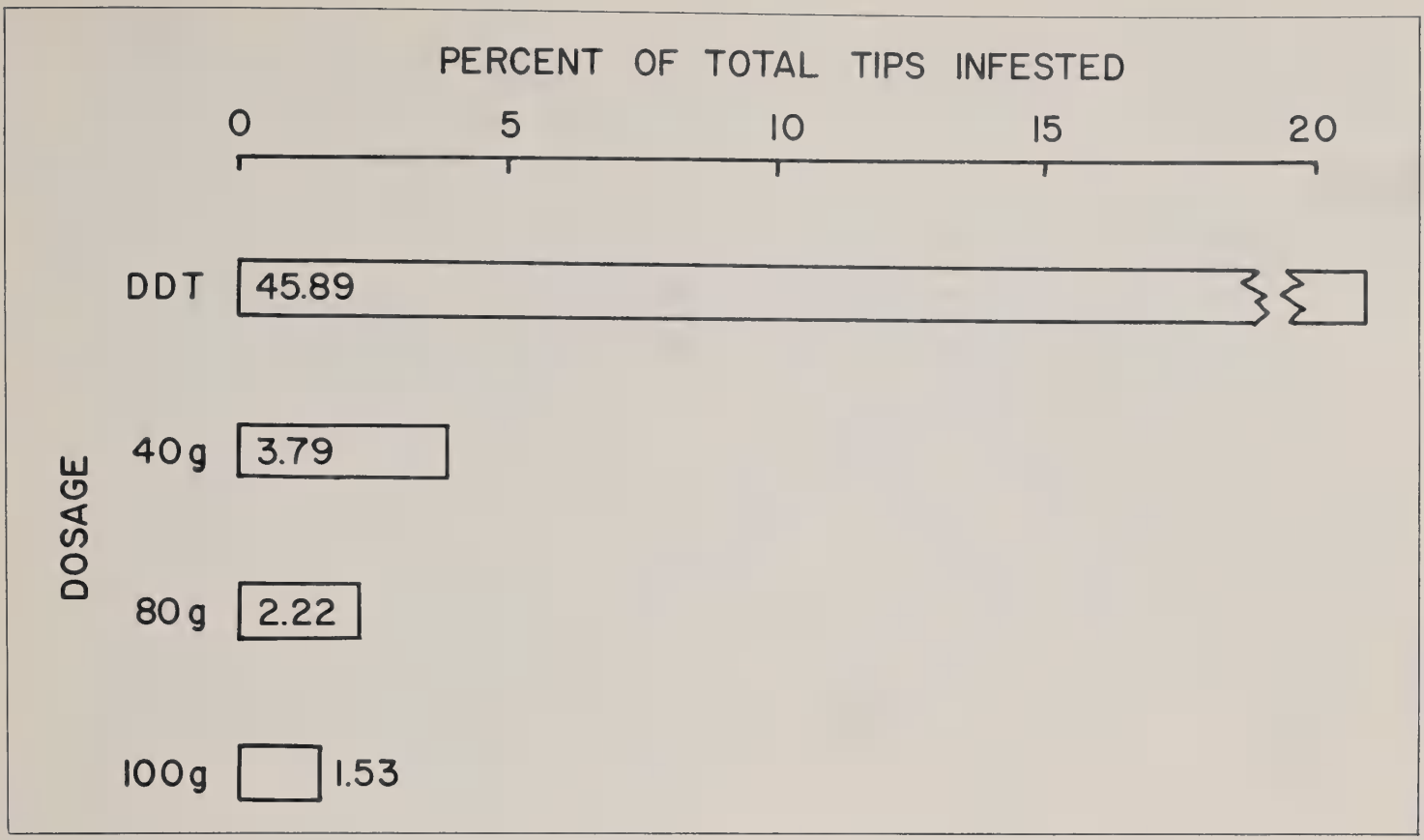

Fig. 3 Comparison of percent tips infested by *R. frustrana* at various phorate dosage rates and DDT. F. H. Claridge State Seed Orchard, Goldsboro, North Carolina — 1968.

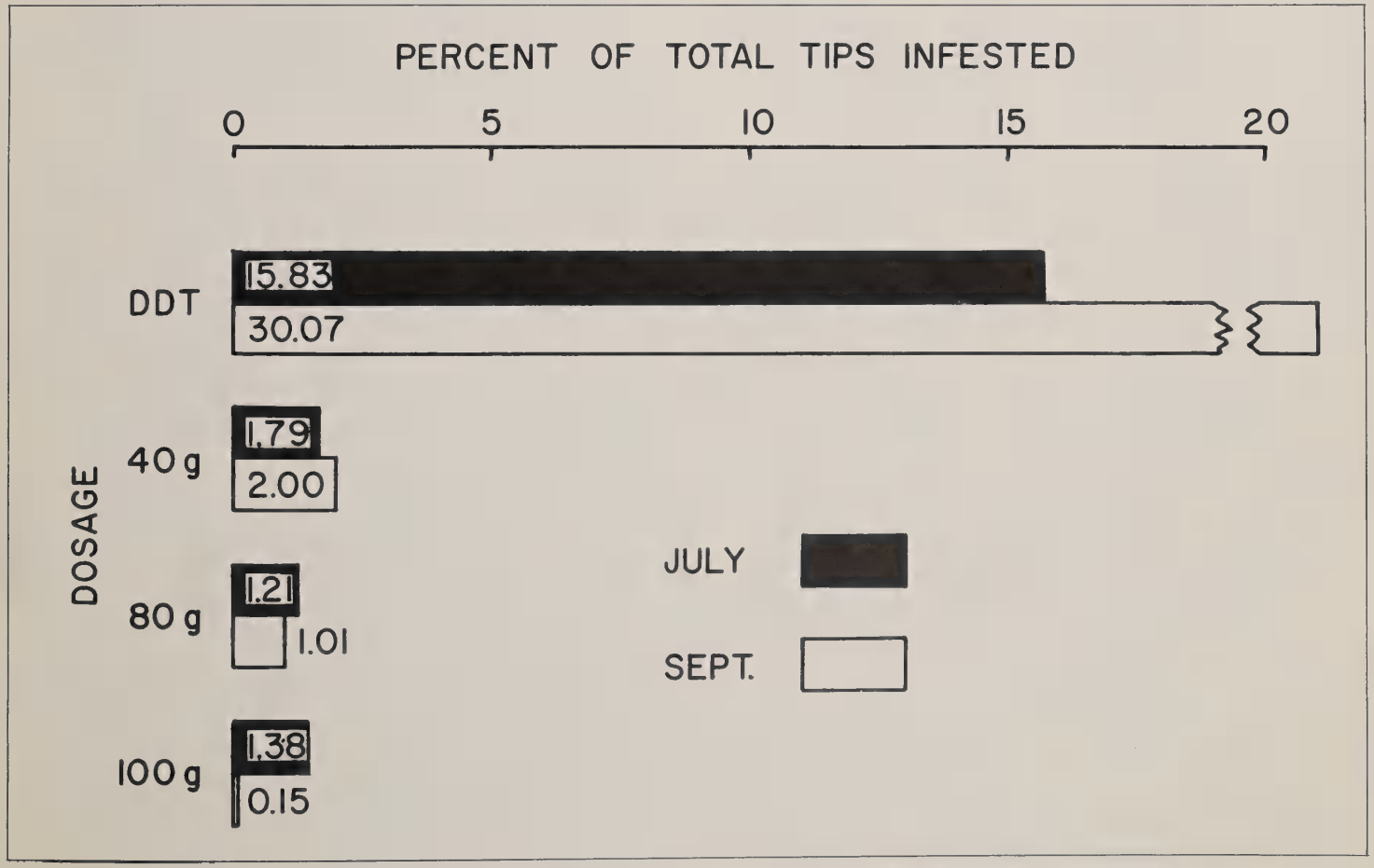

Fig. 4 Percent tips infested by *R. frustrana* at various phorate dosage rates and DDT during July and September. F. H. Claridge State Seed Orchard, Goldsboro, North Carolina — 1968.

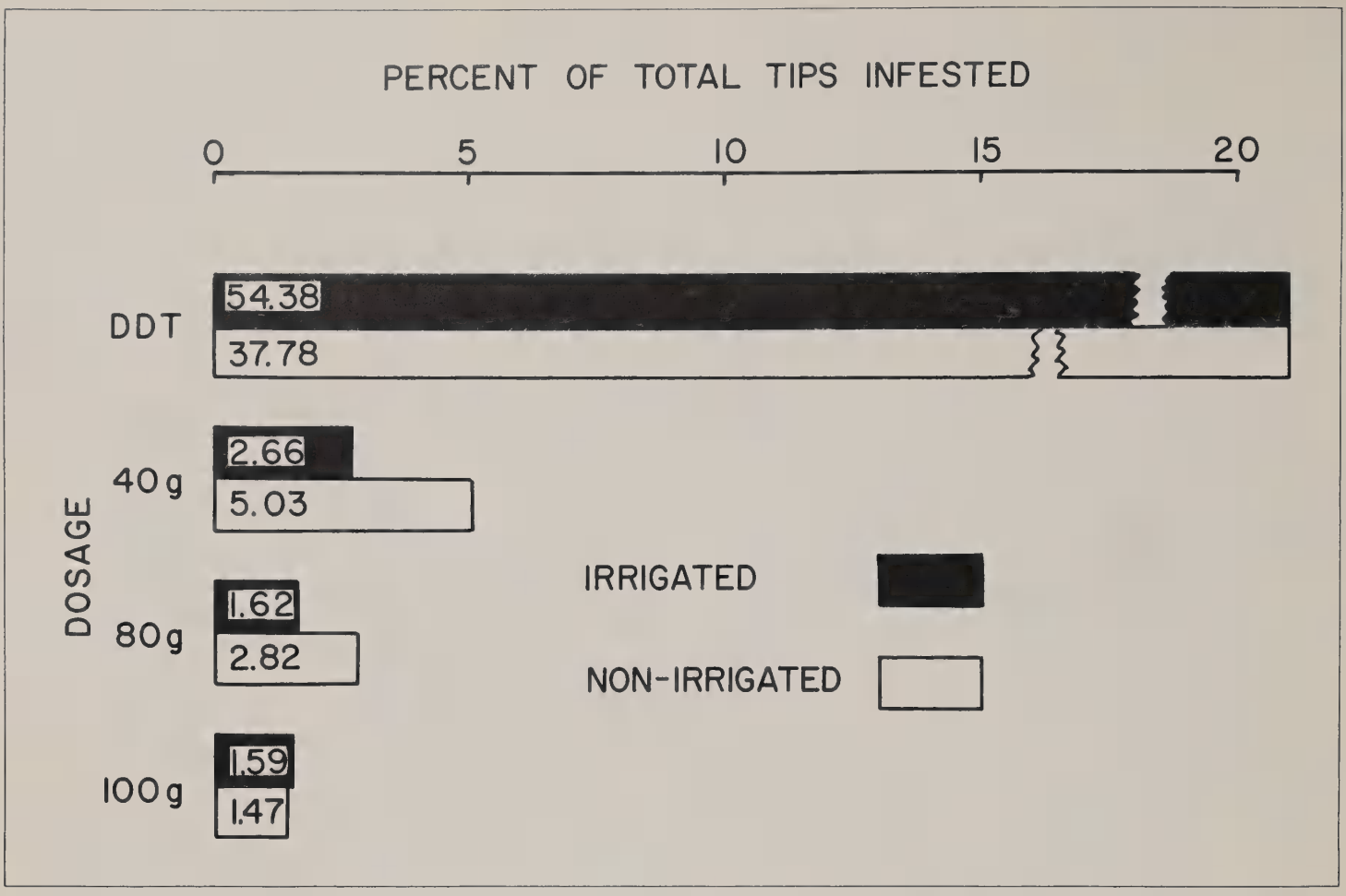

Fig. 5 Percent tips infested by *R. frustrana* at various phorate dosage rates and DDT under irrigated and non-irrigated conditions. F. H. Claridge State Seed Orchard, Goldsboro, North Carolina – 1968.

important. This is illustrated by the fact that there is a progressively lesser difference in infestation level between irrigated and non-irrigated as the phorate dosage increases.

Rainfall, which amounted to 20.14 inches over the seven month test period, was adequate to carry the systemic insecticide into the soil and ultimately to the root system for uptake by the trees.

Residue Analysis

Phorate residue in the form of toxic metabolites were found in various concentrations in the distal branch tips of phorate treated trees. The parts per million residue increased as the dosage rate per tree increased (Table 4).

Residue levels under irrigated and non-irrigated conditions were variable. Samples taken in July indicated that irrigation at the 40 and 80 gram per tree phorate dosage level produced higher toxic metabolite residue levels than those under non-irrigated conditions. At 100 grams per tree however, residue levels were higher under non-irrigated conditions. In September, residue

Table 4 – Summary of phorate (organic phosphorus) residue in living tissue of six trees sampled in July and again in September. F. H. Claridge State Seed Orchard, Goldsboro, North Carolina – 1968.

Treatment		Parts per million residue	
		July	September
40 Gram Dosage	Irrigated	4.2	5.9
	Non-irrigated	3.7	3.5
80 Gram Dosage	Irrigated	6.0	3.8
	Non-irrigated	5.6	6.4
100 Gram Dosage	Irrigated	7.7	14.3
	Non-irrigated	11.2	7.7
CONTROL (Untreated)		1.0	1.0

levels were higher under irrigated conditions in the 40 and 100 gram dosage. At the 80 gram level the converse was true; there were higher residues under non-irrigated conditions.

This variation in residue at individual dosage levels under irrigated and non-irrigated conditions substantiates the statistical analysis of effectiveness data – i.e. There was no significant difference in the control achieved between irrigated and non-irrigated phorate treatments.

The 1.0 parts per million residue level found in the control trees is believed due to naturally occurring metabolites in the soil or from applied fertilizers. Contamination of the samples is possible, but not probable.

Differences in residue levels between samples taken in July and September are interesting to note – At the 40 and 100 gram per tree dosage under irrigated conditions, residue levels increased from July to September. An increase was also recorded at the 80 gram per tree dosage under non-irrigated conditions. Generally, the parts per million phorate residue remained high at all dosage levels under irrigated as well as non-irrigated conditions through the conclusion of the test. This obeservation collaborates and possibly constitutes the reason for the overall continuation of control in phorate treated trees up to and through the conclusion of the pilot test. It also suggests the possibility of control extending into the next year.

Time – Cost Analysis – Phorate vs. DDT

Phorate – A total of 1,000 trees were treated with phorate in seven hours by two sub-professional and two professional personnel using the application techniques described. The two technicians raked the duff away from the base of trees and returned the duff to its original position after the phorate was applied. The two professional personnel loaded the phorate into the application equipment, applied it and decontaminated all equipment upon completion. The total man hours involved in treating 1,000 trees was 14 sub-professional man hours and 14 professional man hours. The average cost of chemical phorate was approximately $0.034 per tree.

DDT Treatment – One tractor operator with a tractor-mounted hydraulic sprayer could spray 1,000 trees in approximately five hours. An additional half-hour was required to mix, load and clean the spray equipment. The total operation required 5.5 man hours per single treatment of 1,000 trees or 33 man hours for the six applications required throughout the season. The insecticide cost of the chemical DDT was $0.024 per tree for the season.

Although insecticide costs were approximately one cent per tree higher in the phorate treatment, the man hours for applying phorate were less than those required for DDT. In this pilot test the overall total cost of treating 1,000 trees with phorate was approximately $10.00 less than treating with DDT.

Although cost figures on the operation and maintenance of hydraulic sprayer equipped tractors were unavailable, it is certain that those costs would far exceed those of the relatively simple phorate application apparatus. Future development of improved equipment for the application of phorate will surely increase the efficiency and further reduce the time and costs of application.

SAFETY

Although precautions are necessary in all insecticide application, extreme caution was warranted and exercised in the use of phorate, a highly toxic organophosphorus. The following are precautions which were taken in this pilot test and are those which are recommended in any future application of phorate.

1. Only trained men who were physically and mentally fit handled the insecticides.

2. Adequate training on the hazards of these insecticides were given to all personnel involved.

3. Handling or consumption of food in or near insecticide mixing areas was prohibited.

4. Personnel working with insecticides washed their hands with soap and water before eating, smoking or using the toilet.

5. A physician was engaged on a stand-by basis for the phorate application in order to be available in the event of an emergency.

6. Protective clothing was worn by all personnel involved in application: (Fig. 6)

   (a) Full length sleeves and pants of a coverall or water-repellent type changed daily during operations.

   (b) Washable or disposable hat

   (c) Rubber gloves

   (d) Slip-on boots

7. Approved respirators were worn by all personnel during insecticide handling, mixing and application.

8. All empty containers were disposed of and all equipment decontaminated in accordance to manufacturer's specifications.

In addition to the above precautions, all rules normally used in applying other conventional pesticides of lesser toxicity were rigidly followed.

Normal safety precautions which apply to moderately toxic insecticides were exercised in the dimethoate applications. Although a systemic, dimethoate is much less toxic than phorate.

Fig. 6 Protective gear essential to the safe application of phorate systemic insecticide.

CONCLUSIONS AND SUMMARY

1. Loblolly seed trees treated with phorate (Thimet 10-G) once in early spring showed significantly less infestation than those treated monthly with DDT. The percent of infested tips in the phorate treated trees ranged between 1.5 and 3.7 percent depending on dosage level while those tips infested in the DDT treatment trees exceeded 45 percent.

2. Irrigation of select phorate treatment blocks to determine relationship of water to the uptake and ultimate effectiveness of phorate revealed no significant differences in degree of control between irrigated and non-irrigated.

3. Laboratory analysis of living pine tips from phorate treated trees for toxic metabolites of phorate in July and September revealed that the residue (parts per million) remained high throughout the test and were actually climbing under some conditions at the climax of the test in September.

4. None of the three separate methods of statistical analysis indicated any significant differential effectiveness among the three phorate treatments (40, 80 and 100 grams per tree) in July. In September however, the 100 gram per tree dosage level was significantly more effective than the 40 gram level. One analysis also indicated that the 80 gram level was more effective than the 40 gram level.

5. At all phorate dosage levels per tree, irregardless of significant differences between the effectiveness of each, tip moth damage was kept within tolerable levels.

6. The cost of the single required application of phorate was less than that of treating monthly with DDT.

7. The use of phorate for control of the tip moth should be considered only on special use areas such as seed orchards or other areas comprised of high value trees. Its application should be restricted to qualified personnel.

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